Háskóli Íslands
Raunvísindadeild
Eðlisfræði

Haust 2016

Eðlisfræði þéttefnis I

Dæmablað 3

Skilafrestur 20. September 2016 kl. 15:00

1. **X-ray diffraction** (15)

   Þegar þú situr fyrir framan gamla litasjónvarpið með 25 kV mætti á myndlampanum þá eru miklar líkur á að þú verðir fyrir Röntgengeislun.

   (a) Hvað er það sem veldur mestu flæði Röntgengeisla ?

   (b) Fyrir samfelldu dreifinguna sem fram kemur, reiknaðu stystu bylgjulengd (hæsta orka) Röntgengeislanna.

   (c) Fyrir salt (NaCl) kristall sem komið er fyrir framan við myndlampann, reiknaðu Bragg horn fyrstu gráðu speglunar við $\lambda = 0.5$ Å. ($\rho_{\mathrm{NaCl}} = 2.165$ g/cm^3 og $M = 58.45$ g/mol).

   When sitting in front of a tube color TV with a 25 kV picture tube potential you have an excellent chance of being irradiated with X-rays.

   (a) What process produces most of the X-ray flux ?

   (b) For the resulting continous distribution, calculate the shortest wavelength (maximum energy) X-ray.

   (c) For a rock salt (NaCl) crystal placed in front of the tube, calculate the Bragg angle for a first order reflection maximum at $\lambda = 0.5$ Å. ($\rho_{\mathrm{NaCl}} = 2.165$ g/cm^3 and $M = 58.45$ g/mol)

   (Próf Maí 2016)

2. **Interplanar separation** (10)

   Consider a plane hkl in a crystal lattice.

   (a) Prove that the reciprocal lattice vector $\mathbf{G} = h\mathbf{b}_1 + k\mathbf{b}_2 + l\mathbf{b}_3$ is perpendicular to this plane.

   (b) Prove that the distance between two adjacent parallel place of the lattice is $d(\text{hkl}) = 2\pi/|\mathbf{G}|$.

   (c) show for a simple cubic lattice that $d^2 = a^2/(h^2 + k^2 + l^2)$.

3. **Hexagonal reciprocal lattice** (10)

   (a) For a hexagonal lattice with primitive lattice vectors $\mathbf{a}_1 = a(1, 0, 0), \mathbf{a}_2 = a(1/2, \sqrt{3}/2, 0), \mathbf{a}_3 = c(0, 0, 1)$ calculate the primitive vectors of the reciprocal lattice using the standard construction shown in class. What type of lattice is the reciprocal lattice ? What is its angle of rotation with respect to the original lattice ?

   (b) Using the reciprocal lattice vectors, calculate the volume of the first Brillouin zone. Draw a careful diagram of the first Brillouin zone in reciprocal space.

4. **Density of atoms in silicon** (10)

   Consider the diamond structure of a Si crystal, for which the cubic lattice constant is $a = 5.431$ Å.

   (a) Compute the distance, in Å, between nearest-neighbor Si atoms in the crystal.

   (b) Compute the distance, in Å, between nearest-neighbor Si atoms in the (100), (110), and (111) planes of the Si crystal.

   (c) Compute the density of atoms (atoms/cm^3) in the Si crystal.